

the second cross-axial pump being flowingly connected to a second adjacent downstream channel,

the second adjacent downstream channel being bounded by a blocking wall on an upstream side and a downstream axial side of the second adjacent channel,

and wherein the mixing section delivers the resulting plastified mixture to an output.

35. (New) An extruder mixer for plastified material comprising a rotatable elongated screw, the screw having a mixing section adapted to mix plastified materials by elongational dispersion, the mixing section having an upstream inlet channel flowingly connected adjacent to one side of a downstream cross-axial pump, the upstream inlet channel constructed and arranged to directly flow into a non-adjacent channel located downstream of the downstream cross-axial pump, whereby the plastified material flows from the upstream inlet channel directly to the non-adjacent channel without communicating through the downstream cross-axial pump.

Remarks

Claim 1 has been replaced by new Claim 34 and we have carefully amended Claims 7-11, 14 and 16 pursuant to the Examiner's helpful suggestions. Claim 34, which replaces Claim 1, is submitted to be free of any indefiniteness under Paragraph 3 of the Official Action and the dependent Claims 7, 9, 10 and 11 have been amended to provide an antecedent basis under the Rules. Claim 35 has also been added. It is similar to original Claim 1 and has been added to stress a distinction over the cited references; that is, a direct communication between the upstream inlet channel and a non-adjacent channel. Claim 6 has also been canceled.

Regarding Claim 14, the term "unconnected" was clearly intended to mean free of any connection.

Claim 15 has been amended by substituting Claim 34 for Claim 1; please see our previous Amendment dated July 25, 2002.

Applicant appreciates the Examiner's helpful comment regarding a correlation between the disclosure and the drawings, and the terminology contained in the claims. In order to provide such a correlation, we respectfully request leave to substitute Claim 34 for Claim 1, which Applicant submits provides detailed answers to the queries raised in Paragraphs 11 and 12 of the Official Action, and to add Claim 35. This correlation will be set forth in the subsequent portions of these remarks.

Turning to Figs. 1A and 1B, and the relevant portions of the specification, it is clear that the helix 28 is driving the materials to be mixed, in a downstream direction by feeding the materials into a first inlet channel 21. First inlet channel 21 has one wall 26 which has a larger cross section than the cross-axial pump 22, thus causing the mixture of materials to be caused to flow crosswise from one channel to the other, and then downstream as well, in a first cross-axial channel formed adjacent to cross-axial pump 22. This is clearly shown in Fig. 1B. The number 23 designates a second channel inlet fed by the cross-axial pump 22, and also flowing in a downstream direction, as was the case in the first inlet channel 21. The second cross inlet channel 23, Fig. 1B, causes the mixture to flow downstream and to the second cross-axial pump 24. This sequence of events may occur twice, as illustrated, or any number of times, as is clearly disclosed in the specification.

The first inlet channel 21 is substantially axially disposed and is in direct communication with an output, such as output channel 24 discussed on page 5, lines 16-22 of the specification and shown in the embodiment of the invention depicted in Fig. 1B. The output channel is adjacent to but downstream of an intermediate cross axial pump, such as pump 22 shown in Fig. 1B. This arrangement enables elongational dispersion of the plastified material flowing into the inlet channels without substantial compression of the material as required in prior art systems.

All of these features are disclosed and specifically defined in Claim 34 and not disclosed in the cited prior art. Claim 34 requires:

- (A) an extruder mixer for plastified flowable materials comprising an elongated rotatable

screw;

- (B) the screw having a mixing section adapted to mix plastified materials with each other;
- (C) the mixing section of the screw having a substantially axially disposed upstream inlet channel that is flowingly directed in a downstream direction, and is bounded on one side by a substantially axially disposed blocking wall,
- (D) the inlet channel being flowingly connected to a substantially axially disposed first cross-axial pump and flowingly connected to a non-adjacent downstream channel,
- (E) the first cross-axial pump being flowingly connected to a first downstream channel,
- (F) the first downstream channel being bounded by a blocking wall on an upstream side of said first downstream channel, and being flowingly connected to a second cross-axial pump,
- (G) the second cross-axial pump being flowingly connected to the non-adjacent downstream channel,
- (H) the non-adjacent downstream channel being bounded by a blocking wall on the an upstream side and a downstream axial side of said non-adjacent channel, and
- (I) wherein the mixing section delivers the resulting plastified mixture to an output.

The plastic material flow can be run with the first inlet channel 21 starved (partially empty) (specification page 5, lines 16-22) conveying material to a first cross-axial pump 22. As the flow accelerates into cross-axial pump 22, an important improvement in mixing is created. Cross-axial pump 22 reorients the material in planar shear while pumping into the second channel inlet 23. Second channel inlet, also running starved, conveys material to the inlet to a subsequent cross-axial pump 24. The cross-axial pump, in Figs. 1A and 1B, conveys the mixture into an output channel, but as previously stated, there can be any number of combinations of the first inlet channel combined with the cross-axial pump 22, as is shown in the other figures of the drawings.

Claim 34 specifies not only that the inlet channel is flowingly connected to a downstream cross-axial pump, but that it is in direct communication with a non-adjacent channel located

downstream of the downstream cross-axial pump. This is in sharp contrast with the prior art.

It is respectfully submitted that with this correlation submitted, and with analogous structures and variations shown in the other figures of the drawings, it is clear that the Applicant's invention involves novel and inventive features neither disclosed nor suggested by any of the cited prior art.

Specifically, it is important to observe that the structure of the mixing section of the Applicant's invention requires only a minimum amount of pressure to be applied to deliver the feed material to the upstream inlet channel of the mixer. Once the incoming plastic material enters the inlet channel, it meets a succession of cross-axial pumping members preferably having substantial clearance with the outer shell of the extruder as disclosed in page 4 of the specification, line 5 and elsewhere. Each cross-axial pumping member takes on a cross-axial pumping function, effective at an angle to the extruder axis, which exceeds the inlet flow. Thus, the pumping function causes the inlet channel to become partially empty, or "starved." The plastic material that approaches each cross-axial pump is then stressed under reorientation in planar shear rather than straight compression, and remarkable mixing dispersion takes place. Claim 34 includes this feature by reciting a mixing section in which the inlet channel is in direct communication with a non-adjacent channel. This inventive direct communication of elements within the mixing section enables elongational dispersion of the plastified material, which is a highly beneficial condition not present in prior art systems.

It is further noteworthy that, as the plastic materials mixture moves over each cross-axial pump, the materials are reoriented in a planar shear field. These successive reorientations take place in the absence of a worm flight, as to generate pressure between two successive mixing elements, as required by Araki and Housz and discussed in greater detail below.

In accordance with the Applicant's invention, this effect is further augmented, when desired by the operator, by providing starve feeding of the plastic feed into the extruder. This starve feeding can be controlled or assisted by a screw design but in any event adds a great deal of flexibility to the

process and makes it highly novel and useful. Indeed, as disclosed at page 4, lines 16 and 17, an additional feed rate to fill the end of the inlet channel with plastic material can be used as a control if desired.

Turning now to the prior art in greater detail, with the foregoing concepts and principles in mind, it is important to realize that Araki '790 simply has two sets of continuously flowing, helically arranged passageways x and y (Araki Fig. 1). While there are variations of flow rates of the rubber particles flowing in these axial paths, there is no combination of the type defined in Claim 34 and clearly shown in Applicant's Figs. 1A and 1B, for example, where a first downstream inlet channel feeds into a cross-fed cross-axial channel, which in turn feeds into a subsequent channel inlet 23 and which in turn feeds in a downstream direction into a subsequent cross-axial mixer 24, etc., etc. It is this sideways slip created by Applicant's claimed extruder mixer that forms a direct connection between the inlet channel and the output, coupled with repeated applications of alternating pumping functions causing the inlet channel to become partially emptied, and where the material that approaches each cross-axial pump is stressed in elongation rather than compression, that produces remarkable mixing dispersion and clearly distinguishes Applicant's invention from Araki.

In short, Applicant's invention differs sharply from Araki '790 in that, although there are variations of flow rates of a rubber, the Araki extruder requires the material to be kept in the same helical path throughout, from the beginning to the end of the extrusion process. The structures disclosed by Araki (and Housz) therefor, create *pushing forces* as opposed to the *pulling forces* created by the elongational flow fields formed by Applicant's claimed structures.

It is important to further carefully consider the portion of Araki '790 at column 2, line 61 through column 3, line 14, that the Araki device is using a change of shear section in one and the same helical passageway only for the purpose of warming rubber without causing stagnation of the rubber, and does not achieve cross directed elongation and compression but simply changes the flow rate of the rubber along its constant path.

In Araki, the grooves 5 are bounded on both sides, and the Araki channels and pumps are positioned between spires, as disclosed at Araki column 2, lines 11-20, confirming that the spires of the helix extend helically therearound, and do not have any channels such as Applicant's 21, 22, 23 and 24 of Fig. 1(a) which are oriented in a downstream direction, alternating with cross-directions.

Turning now to Housz, his inlet is bounded by dams 16; the first ridge 13 prevents passage of molten material therethrough.

In Housz, the inlet is a screw 4 and the exit is a screw pump that is not in contact with the screw 4 because of the intervention of the heater section 11. With first ridges 13 and second ridges 14, these intervening members are not intended or constructed to create alternate stretching and compression of the thermoplastic material but only to melt it. There would be no way for Housz' apparatus to create the reorientation of the material in planar shear while pumping into Applicant's second channel inlet 23, which pumps into the cross-axial pump 24, reorienting the mixed plastic material in planar shear. Thus, each of Applicant's cross-axial pumps reorients the material further. The number is not restricted--in Fig. 4 of Applicant there are fifteen channel sections 11 and fifteen coaxial pumps with only one outlet.

The Housz reference emphasizes an important difference from the Applicant's invention in that Housz' objective stated at the bottom of column 2 is that the supply of heat takes place at least substantially over an axial distance in the melting apparatus. This, of course, has nothing to do with the Applicant's invention as described in detail in these remarks and as set forth in the Applicant's solicited claims.

In response to the Examiner's comments in paragraph 14 of the Office Action, Applicant respectfully submits that Fig 1B shows that the first inlet channel 21 is bounded only on one side by flight 26. The Examiner states that the first inlet channel is also bounded by "flight 22". However, number 22 is a "cross axial pump 22", not "flight 22", and the inlet channel is not bounded by the

cross axial pump 22, as shown by the direct connection between the first inlet channel 21 and the output depicted in Fig. 1B and elsewhere.

In view of the foregoing, applicant respectfully requests allowance of the pending claims.

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2. (Amended) The apparatus of Claim 34, wherein the cross-axial pumps are bounded by channels on more than one side.

3. (Twice Amended) The apparatus of Claim 34, wherein an upstream feeder is flowingly connected to cause and to control input feed of mixable materials.

4. (Twice Amended) The apparatus of Claim 34, where a screw channel is provided at the input of said mixer and flowingly connected to control the flow rate mixer input.

5. (Twice Amended) The apparatus of Claim 34, where an output flight is flowingly connected to at least one of the blocking walls of the mixing section.

7. (Amended) The apparatus of Claim 34, wherein the dimensions of said upstream and said downstream channels are substantially the same as each other.

8. (Amended) The apparatus of Claim 34, wherein the extruder screw further comprises a mounting directed in a direction wherein said extruder screw is substantially vertically oriented.

9. (Amended) The apparatus of Claim 34, wherein the dimensions of said upstream and said downstream channels are different from each other.

10. (Amended) The apparatus of Claim 34, wherein the dimensions of said upstream and said downstream cross-axial pumps are the same.

11. (Amended) The apparatus of Claim 34, wherein the dimensions of said upstream and said downstream cross-axial pumps are different from each other.

12. (Amended) The apparatus of Claim 34, wherein said channels are oriented substantially parallel to the screw axis.

13. (Amended) The apparatus of Claim 34, wherein the channels are oriented at an angle to the screw axis.

14. (Amended) The apparatus of Claim 34, wherein at least some of the channels are free of connection to said inlet channel.

16. (Amended) The apparatus of Claim 34, wherein the mixer includes a controller for controlling said feed so that said mixer is not starved.

17. (Twice Amended) The apparatus of Claim 34, where resistance devices are provided on said screw to force the plastic material into the output.

18. (Amended) The apparatus of Claim 34, wherein there are multiple inlet channels.

19. (Twice Amended) The apparatus of Claim 34, wherein there are multiple flowingly connected inlet flights.

20. (Twice Amended) The apparatus of Claim 34, wherein there are multiple flowingly connected outlet flights.

34. (New) An extruder mixer for plastified flowable materials comprising:

an elongated rotatable screw;

the screw having a mixing section adapted to mix materials with each other,

the mixing section of the screw having a substantially axially disposed upstream inlet channel,

the inlet channel being flowingly directed in a downstream direction,

said inlet channel being bounded on one side by a substantially axially disposed blocking wall,

the inlet channel being flowingly connected to a substantially axially disposed first cross-axial pump and flowingly connected to a non-adjacent downstream channel, wherein the flowing connection between the inlet channel and the non-adjacent downstream channel is a direct connection free of a flowing connection to the first cross-axial pump;

the first cross-axial pump being flowingly connected to a first downstream channel,

the first downstream channel being bounded by a blocking wall on an upstream side of the first downstream channel,

the first downstream channel being flowingly connected to a second cross-axial pump,

the second cross-axial pump being flowingly connected to a second adjacent downstream channel,

the second adjacent downstream channel being bounded by a blocking wall on an upstream side and a downstream axial side of the second adjacent channel,

and wherein the mixing section delivers the resulting plastified mixture to an output.

35. (New) An extruder mixer for plastified material comprising a rotatable elongated screw, the screw having a mixing section adapted to mix plastified materials by elongational dispersion, the mixing section having an upstream inlet channel flowingly connected adjacent to one side of a downstream cross-axial pump, the upstream inlet channel constructed and arranged to directly flow into a non-adjacent channel located downstream of the downstream cross-axial pump, whereby the plastified material flows from the upstream inlet channel directly to the non-adjacent channel without communicating through the downstream cross-axial pump.